

# COMPUTER PROGRAMMING

## POINTERS

8<sup>TH</sup> WEEK LECTURE

엄현상(Eom, Hyeonsang)  
School of Computer Science and Engineering  
Seoul National University

# Outline

- Pointer Basic
- Pointer Arithmetic
- Function Pointers
- String Basic
- String Functions
- Q&A

# sizeof operator

- Returns size of operand in bytes (at compile-time)
  - For arrays, sizeof returns
    - ( size of an element ) \* ( number of elements )
- ```
int myArray[ 10 ];  
cout << sizeof( myArray );
```

# sizeof operator Cont'd

- Can be used with
  - Variable names
  - Type names
  - Constant values
- Parentheses are only required if the operand is a type name

# Pointer Arithmetic

- Increment/decrement pointer (++ or --)
- Add/subtract an integer to/from a pointer (+ or +=, - or -=)
- Pointers may be subtracted from each other
- Pointer arithmetic is meaningless unless performed on a pointer to an array

# Pointer Arithmetic Cont'd

- 5-element int array on a machine using 4-byte int
  - `vPtr = &v[ 0 ];`
  - vPtr points to first element v[ 0 ], at location 3000
  - `vPtr += 2;`
  - sets vPtr to 3008 ( $3000 + 2 * 4$ )
  - vPtr points to v[ 2 ]
- Subtracting pointers
  - Returns number of elements between two addresses
  - `vPtr2 = &v[ 2 ]; vPtr = &v[ 0 ]; vPtr2 - vPtr ?`

# Pointer Arithmetic Cont'd

- Pointer can be assigned to another pointer if both are of same type
  - If not, use cast operator
  - Pointer to void (void \*)
    - Generic pointer, represents any type
    - No casting needed to convert pointer to void \*
    - Casting is needed to convert void \* to any other type
    - void pointers cannot be dereferenced

# Pointer Arithmetic Cont'd

- Pointer comparison
  - Use equality and relational operators
  - Compare addresses stored in pointers
    - Comparisons are meaningless unless pointers point to members of the same array
  - When checking whether pointer is 0 (null pointer)
- Arrays and pointers are closely related
  - Array name is like constant pointer
  - Pointers can do array subscripting operations



# Pointer Arithmetic Cont'd

```
int b[] = { 10, 20, 30, 40 };  
int *bPtr = b;
```

...

```
for( int i = 0; i < 4; i++ )  
    cout << "b[" << i << "]=";  
    cout << b[ i ] << endl;
```

```
for( int f1 = 0; f1 < 4;  
    f1++ )  
    cout << "(b+" << f1;  
    cout << ")=";  
    cout << *(b+f1) << endl;
```

```
int b[] = { 10, 20, 30, 40 };  
int *bPtr = b;
```

...

```
for( int i = 0; i < 4; i++ )  
    cout << "b[" << i << "]=";  
    cout << b[ i ] << endl;
```

```
for( int f1 = 0; f1 < 4;  
    f1++ )  
    cout << "(b+" << f1;  
    cout << ")=";  
    cout << *(b+f1) << endl;
```

# Arrays of Pointers

```
const char *a[ 4 ] =  
    { "Hearts", "Diamonds", "Clubs", "Spades" };
```

- Each element of a points to a char \* (string)
- Array a has fixed size (4), but strings can be of any size
- Commonly used with command-line arguments to function main

# Pointers to Functions

- Contain addresses of functions
  - Function name is starting address of code that defines function
- Passed to functions
- Returned from functions
- Stored in arrays
- Assigned to other function pointers

# Calling Functions using Pointers

- Function header  
`bool ( *foo ) ( int, int )`
- Execute function from pointer with either  
`( *foo ) ( x, y )`
  - Dereference pointer to function, or  
`foo( x, y )`
  - Use the pointer directly
    - Could be confusing

# Function Pointers

```
void selectionSort( int [],
    const int,
    bool (*)( int, int ) );

void swap( int * const,
    int * const );

bool ascending( int, int );
bool descending( int, int );

int main()
{
    const int aSize = 10;
    int order;
    int counter;

    int a[ aSize ] =
        { 2, 6, 4, 8, 10,
          12, 89, 68, 45, 37 };

    ...
    cin >> order;
    if ( order == 1 ) {
        selectionSort( a, aSize,
                       ascending );
    }
    else
    {
        selectionSort( a, aSize,
                       descending );
    }
    ...
}
```

# Function Pointers Cont'd

```
void selectionSort( int w[], const int size, bool
    (*compare)( int, int ) )
{
    int smallestOrLargest;

    for ( int i=0;
        i<size - 1; i++ )
    {
        sorl = i;

        for ( int idx = i + 1;
            idx < size;
            idx++ )
            if( !(*compare)
                ( w[sorl], work[idx] ) )
                sorl = idx;

        swap(&work[sorl], &work[i]);
    }
}
```

# Function Pointers Cont'd

```
void swap( int * const element1Ptr, int * const element2Ptr )
{
    int hold = *element1Ptr;

    *element1Ptr = *element2Ptr;

    *element2Ptr = hold;
}
```

```
bool ascending( int a, int b )
{
    return a < b;
}
```

```
bool descending( int a, int b )
{
    return a > b;
}
```

# Arrays of Pointers to Functions

- Menu-driven systems
  - Pointers to each function stored in array of pointers to functions
    - All functions must have same return type and same parameter types
  - Menu choice determines subscript into array of function pointers



# Character Constant and String

- Integer value represented as character in single quotes
  - 'z' is integer value of z
    - 122 in ASCII
  - '\n' is integer value of newline
    - 10 in ASCII
- String
  - Series of characters treated as single unit
  - String literal (string constants)
    - "I like C++"
    - Static storage class
  - Array of characters, ends with null character '\0'
  - String is constant pointer to string's first character

# String Assignment

- Character array
  - `char color[] = "blue";`
  - `char color[] = { 'b', 'l', 'u', 'e', '\0' };`
  - Creates 5 element char array color
  - Last element is '\0'
- Variable of type **char \***
  - `char *colorPtr = "blue";`
  - Creates pointer colorPtr to letter b in string "blue"
  - "blue" resides somewhere in memory

# Reading Strings

- Assign input to character array **word[ 20 ]**  
**cin >> word;**
  - Reads characters until whitespace or EOF
  - Reads only up to 19 characters (space reserved for '\0')
- String could exceed array size  
**cin >> setw( 20 ) >> word;**

# cin.getline

- Read line of text

**cin.getline( array, size, delimiter );**

- Copies input into specified array until either
  - One less than size is reached
  - Delimiter character is input

**char sentence[ 80 ];**

**cin.getline( sentence, 80, '\n' );**

# <cstring> Library

- Manipulate string data
- Compare strings
- Search strings for characters and other strings
- Tokenize strings (separate strings into logical pieces)
- Data type **size\_t**
  - An unsigned integral type
    - Such as unsigned int or unsigned long
  - Defined in header file <cstring>

# String Functions

- **char \*strcpy( char \*s1, const char \*s2 )**
  - Copies second argument into first argument
    - First argument must be large enough to store string and terminating null character
- **char \*strncpy( char \*s1, const char \*s2, size\_t n )**
  - Specifies number of characters to be copied from second argument into first argument
    - Does not necessarily copy terminating null character
- **char \*strcat( char \*s1, const char \*s2 )**
  - Appends second argument to first argument
    - First character of second argument replaces null character terminating first argument
    - You must ensure first argument large enough to store concatenated result and null character
- **char \*strncat( char \*s1, const char \*s2, size\_t n )**
  - Appends specified number of characters from second argument to first argument
    - Appends terminating null character to result
- **size\_t strlen( const char \*s )**
  - Returns number of characters in string

# String Functions Cont'd

- **int strcmp( const char \*s1, const char \*s2 )**
  - Compares character by character
  - Returns
    - Zero if strings are equal
    - Negative value if first string is less than second string
    - Positive value if first string is greater than second string
- **int strncmp( const char \*s1, const char \*s2, size\_t n )**
  - Compares up to specified number of characters
    - Stops if it reaches null character in one of arguments
- Character codes / character sets
  - Machine dependent
  - ASCII
    - “American Standard Code for Information Interchange”
  - EBCDIC
    - “Extended Binary Coded Decimal Interchange Code”
  - Unicode

# Tokenizing

- Breaking strings into tokens
  - Tokens: logical units, such as words (separated by spaces)
  - Separated by delimiting characters
  - "This is my string"
    - 4 word tokens (separated by spaces)
- **char \*strtok( char \*s1, const char \*s2 )**
  - Multiple calls required
    - First call contains two arguments, string to be tokenized and string containing delimiting characters
      - Finds next delimiting character and replaces with null character
    - Subsequent calls continue tokenizing
      - Call with first argument NULL
      - Stores pointer to remaining string in a static variable
  - Returns pointer to current token



# String Example

```
...
#include <cstring> // prototype for strtok
using std::strtok;

int main()
{
    char sentence[] = "This is a sentence with 7 tokens";
    char *tokenPtr;
    tokenPtr = strtok( sentence, " " );
    while ( tokenPtr != NULL )
    {
        cout << tokenPtr << '\n';
        tokenPtr = strtok( NULL, " " );
    }
    cout << "\nAfter strtok, sentence = " << sentence
    << endl;
    return 0;
}
```